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Exploring biases in radiocarbon chronologies: The Iberian Mesolithic-Neolithic transition in light of Antonio Gilman's Carbon-14 Database

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One of the many valuable contributions of Prof. Antonio Gilman to Prehistoric Archaeology is the *Radiocarbon Database of Iberian Late Prehistory* (Uriarte *et alii* 2017). It is the result of a long-lasting and systematic collection work, since 1982, of archaeological radiocarbon dates on Iberian Late Prehistory. Published dates in archaeological bibliography are the main information source, with the estimable addition of unpublished dates from the Geochronology Laboratory in the Rocasolano Institute of the Spanish National Research Council (CSIC). These dates were generously ceded by Antonio Rubinos, responsible of this laboratory till 2014, year of its closing. Also, we must stress the usefulness of other collection works, like the publication by Castro, Lull and Micó (1996) on Iberian and Balearic Late Prehistory chronology or the radiocarbon database for the Catalonian territory, organized by Joan Barceló[1].

The Gilman Archive, still growing, gathers nowadays 9058 dates from 1870 archaeological sites, mainly from Mesolithic to Iron Age chronologies (Fig. 1). Information about each radiocarbon date refers to its technical features (the radiocarbon age with its standard deviation, the lab code, the measure method, and other values like $\delta^{13}C$). It also contains information about the archaeological context,

[1] La base de dades radiocarbòniques de Catalunya: http://www.telearchaeology.org/c14/

both the dated material (type of sample, type of material, taxonomy, stratigraphic context) and the archaeological site (place name, a brief general description, geographic coordinates, chronological and typological descriptors, administrative units). Bibliographical references on radiocarbon dates and archaeological sites are also included.

In accordance with an open data paradigm, we approached the creation of an information system to give public online access to the Gilman Archive. Access is possible through the *IDEArq* platform[2], a Spatial Data Infrastructure for the online publication of repertories of georeferenced archaeological information hosted by the Spanish National Research Council (CSIC). It is the result of the collaboration between the GIS Laboratory (uSIG, CCHS-CSIC), the Research Group *Economic and Social Prehistory* (GIPSE, Instituto de Historia CSIC) and the Landscape Archaeology and Remote Sensing Laboratory (LabTel, Instituto de Historia CSIC), besides the active collaboration of Prof. Antonio Gilman itself. IDEArq was officially presented in September 2016 in the National Archaeological Museum in Madrid (Del Bosque and Vicent 2016) and in October 2016 in Barcelona in the Ibercrono conference on "Chronometry for the History of the Iberian Peninsula" (Uriarte *et alii* 2017).

The information system is based in open source software and, in general terms, consists of a relational database that gathers the information and several interfaces that give public online access to this information. The database hosts the datasets, including the Gilman Archive, and relies on a complex but harmonized conceptual model. The interfaces are the following:

- A set of Web Map Services that allow consuming the information in different kinds of platforms (for example, GIS software or geographical web viewers).
- A geographical viewer in which we can query the archaeological datasets through the archaeological sites.
- A recently developed query interface, still in test phase, for filtering lists of radiocarbon dates through thematic queries, based on the attributes of the dates themselves, the archaeological materials and the archaeological sites.

The Gilman Archive has an obvious primary utility as a source of chronometric information for researchers interested on specific archaeological contexts. But also,

[2] IDEArq. Infraestructura de Datos Espaciales de Investigación Arqueológica: http://www.idearqueologia.org/

due to its comprehensive character, has a great potential for global approaches to Late Prehistory in the Iberian Peninsula. For example:

- Historiographical studies on Iberian archaeology.
- Studies on prehistoric demography, using radiocarbon dates as a proxy of human activity and settlement density. These approaches are based mainly on summed calibrated date probability distributions (SCDPD).
- Palaeoclimatic issues through isotopic information, such as $\delta^{13}C$ values.
- And also as a proxy of the variable "research intensity", assuming that the production of radiocarbon dates in Prehistoric Archaeology is, in a certain degree, directly related to the intensity or archaeological research.

For example, here we have several of these applications based on the Gilman Archive:

- A brief historiographical approach to Iberian Prehistory research, showing the territorial evolution of radiocarbon dates production (Uriarte *et alii* 2017: 217-224).
- A demographic study by Balsera *et alii* (2015), with an estimation of the demographic growth curve since 7000 to 2000 cal BC.
- A multi-proxy research, by Lillios *et alii* (2016), on the Copper to Bronze Age transition. It combines, as palaeoclimatic and palaeodemographic proxies, radiocarbon dates, $\delta^{13}C$ values on C3 plants, and palynological records.

Here we want to introduce a first brief approach to the spatial and chronological distribution of Iberian radiocarbon dates as a proxy for variations in the intensity of research. This is a slippery variable frequently assumed as a cause of data bias in interpretative debates, but hardly ever accurately objectified. Our inquiry is illustrated taking as a case study the Mesolithic-Neolithic transition, where the hypothetical existence of uninhabited regions during the Mesolithic plays a key role in most accounts. Those familiarized with this fascinating subject know the relevant role of radiocarbon dates in the definition of demographic concentrations and holes, its evolution through time and the definition of spreading routes of Neolithic items (like domestic species, new technologies or cultural traits) and maybe foreign people.

As a recent example, we have a publication by García-Puchol *et alii* (2018) with an application of date density maps based on summed calibrated date probability distributions. Valuating 200-year intervals into the 7200-4200 cal BC timespan, they explore variations of radiocarbon date densities as plausible indicators of demographic

concentrations and holes. Our question is: is it possible that this fills and holes are related, at least partially, to research intensity, acting radiocarbon dates as a proxy of this? By analysing the spatial and chronological distribution of radiocarbon dates, we evaluate the likelihood that these vacuums are due to regional research biases. If so, we would probably have an "apparent archaeological context", using the appropriate expression by Joan Bernabeu *et alii* (1999).

For this task, we have regionally compared the distribution of 6th millennium cal BC sites with the rest of the whole set of dated sites in the Gilman Archive. If there is a strong correlation, we will be able to presume that research intensity has a relevant role in the explanation of apparent "demographic holes". The analysis process has been the following:

- First, we have calibrated the whole set of radiocarbon dates, leaving aside those with standard deviations higher than 200. We have used the OxCal online application[3], with the IntCal13 calibration curve.
- Then, we have divided the whole list of archaeological sites into two groups: those with calibrated dates that intersect with the 6th millennium spam and those that do not, that is, the rest of sites.
- A first visual comparison of the geographical distribution of both groups suggests a similar pattern, showing more 6th millennium sites where there are more sites in general (Fig. 2). This impression is reinforced if we use kernel density maps elaborated through ArcGIS software (Figs. 3-4).
- In order to perform a statistical comparison we have grouped the archaeological sites by territorial units. As territorial units we have used the level 2 of Nomenclature of Territorial Units for Statistics by the European Union (NUTS2) (Fig. 5). And then we have calculated the density of archaeological sites for each region (in this case, number of sites per 100 sq km) (Figs. 6-7).
- With these data, we have performed a regression analysis, comparing both densities (that is, 6th millennium sites density *versus* the rest of sites density). The analysis shows a strong correlation, with an R^2 value of 0.71 (Fig. 8). This correlation is even stronger if we use the logarithms of densities (with an R^2 of 0.76) (Fig. 9).

We have repeated the same process for 7th millennium sites (Fig. 10), with similar positive results: R^2 value is equal to 0.61 (Fig. 11) and, with the logarithm values, equal to 0.75) (Fig. 12).

[3] OxCal: https://c14.arch.ox.ac.uk/oxcal.html

Then, we can assume that the spatial distribution of 6th millennium (and also 7th millennium) archaeological sites depends on research intensity, in a certain high degree. So, we cannot discard the possibility that supposed “demographic holes” are “apparent archeological contexts”. Further research incorporating other variables related to research intensity (like archaeological interventions, public works or urban growth) will allow us to reinforce or weaken this idea.

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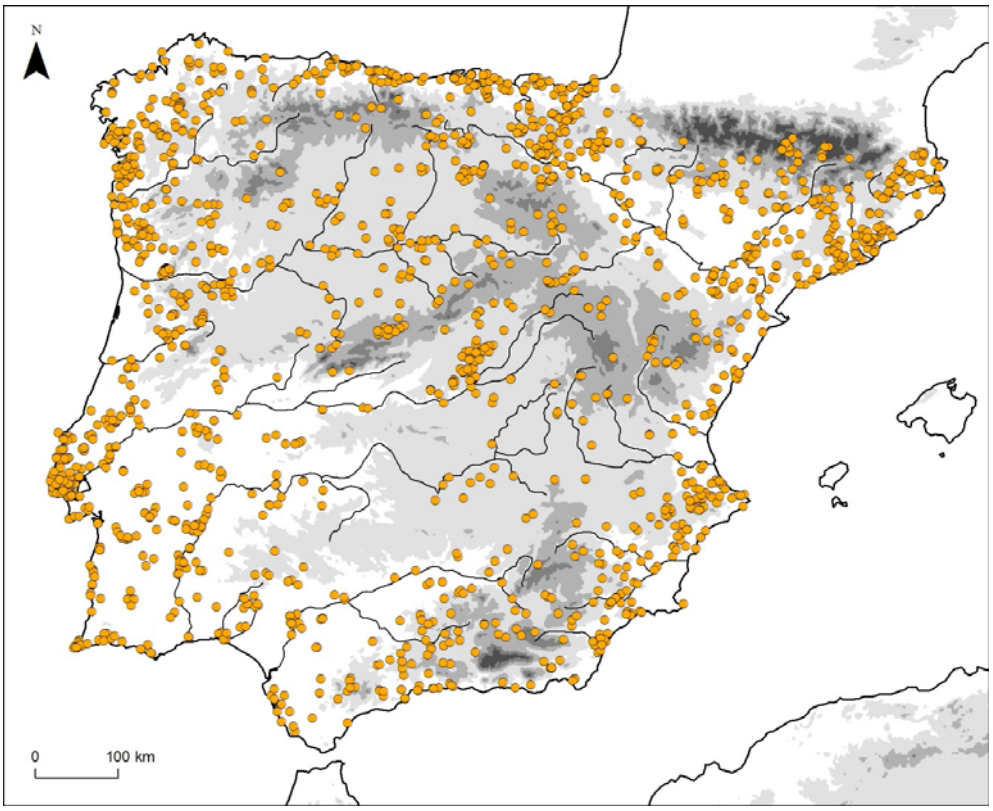

Figure 1. Archaeological sites in the *Radiocarbon Database of Iberian Late Prehistory*.

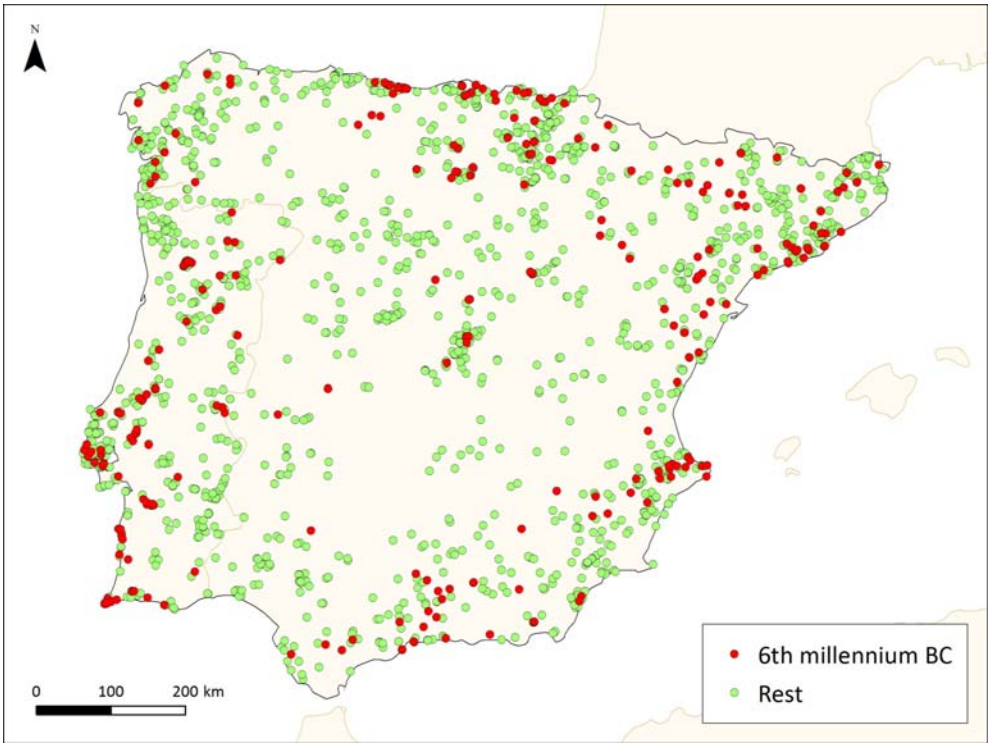

Figure 2. Archaeological sites in the *Radiocarbon Database of Iberian Late Prehistory*, classified into two groups: 6th millennium BC and the rest.

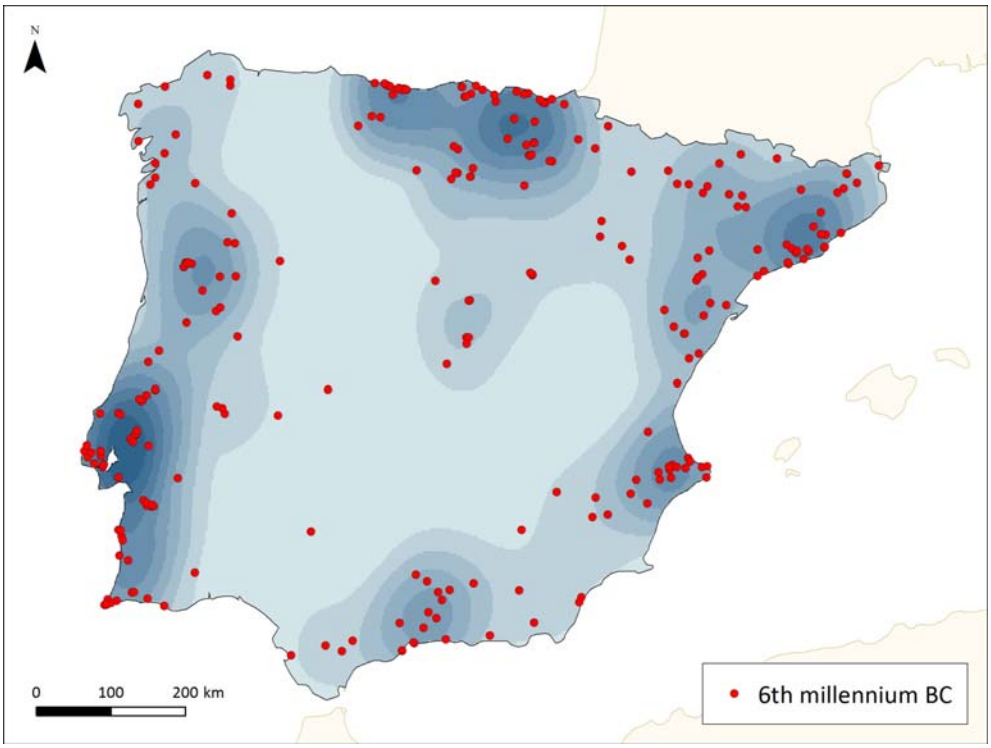

Figure 3. Kernel density map based on 6th millennium BC sites in the *Radiocarbon Database of Iberian Late Prehistory*.

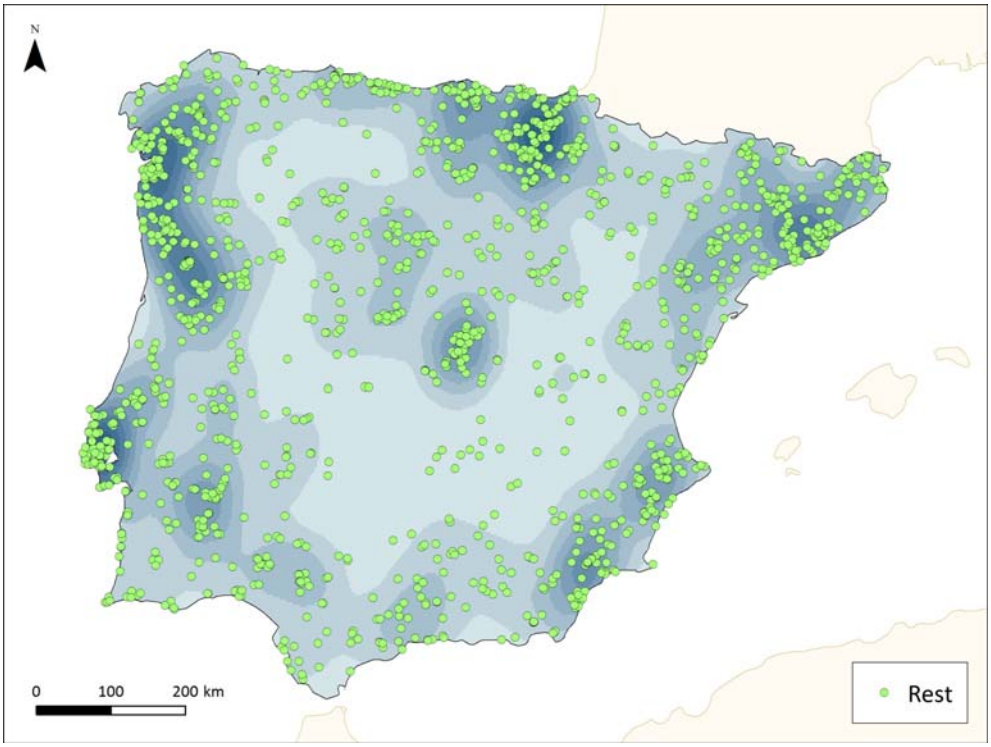

Figure 4. Kernel density map based on non 6th millennium BC sites in the *Radiocarbon Database of Iberian Late Prehistory*.

Figure 5. Territorial units in the Iberian Peninsula according the level 2 of the Nomenclature of Territorial Units for Statistics (NUTS2).

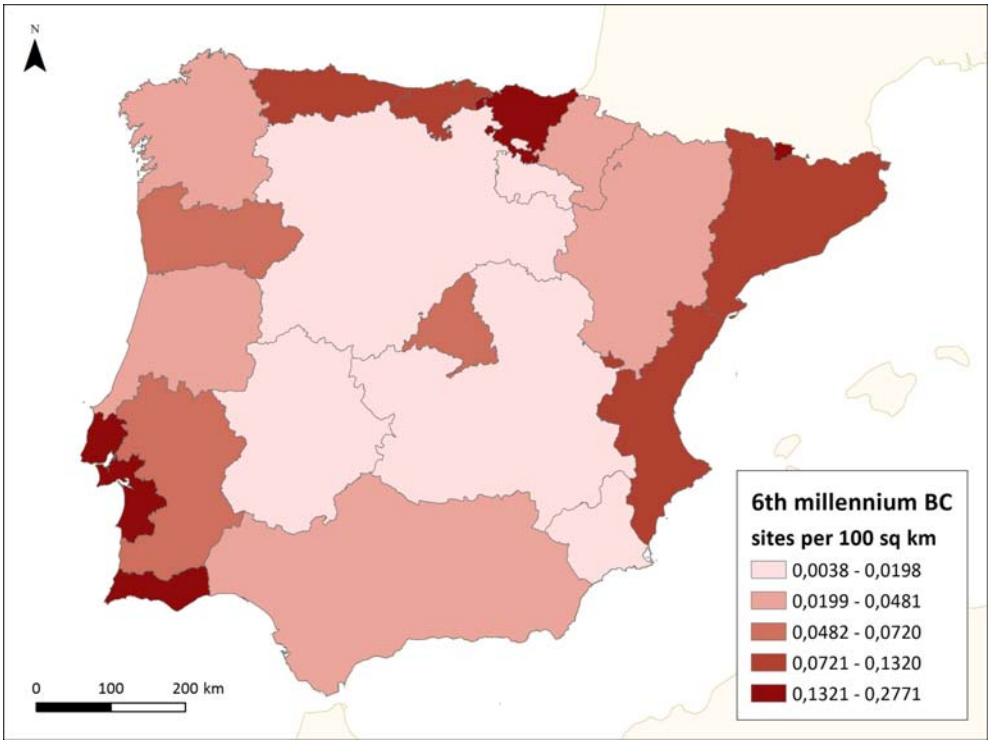

Figure 6. Density of archaeological sites (6th millennium) by NUTS2.

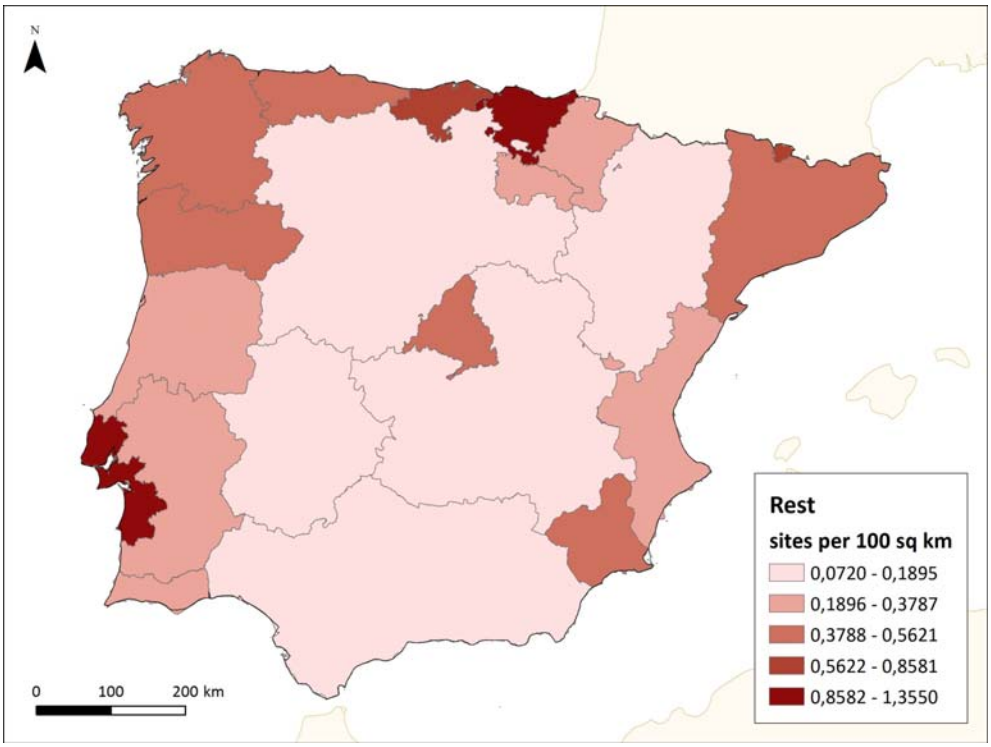

Figure 7. Density of archaeological sites (non 6th millennium) by NUTS2.

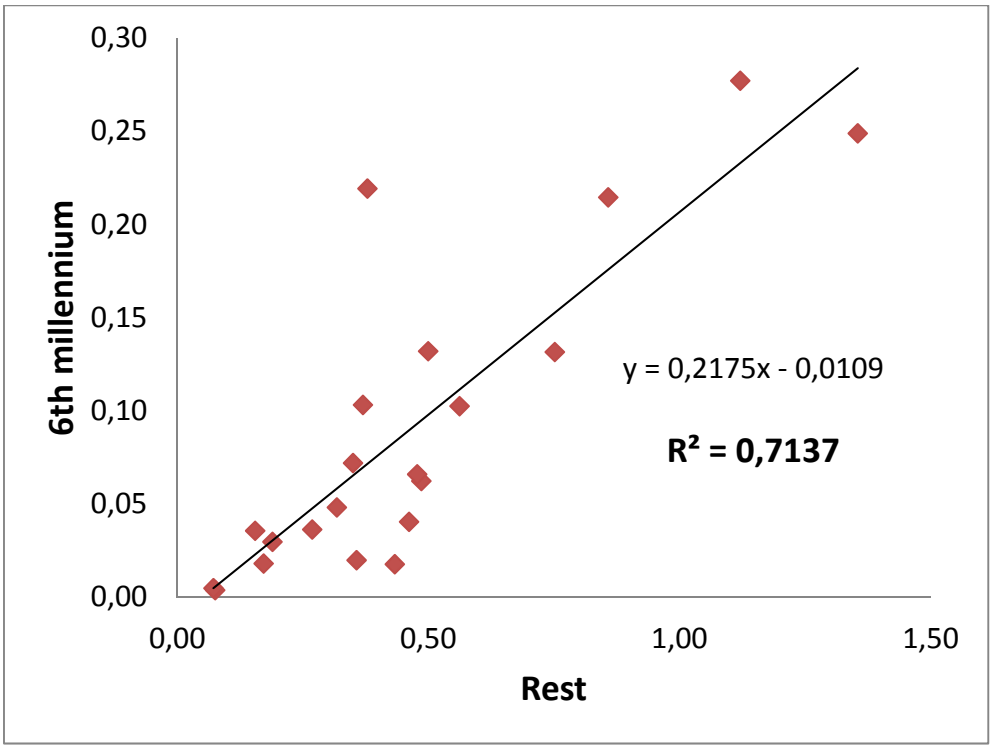

Figure 8. Regression analysis comparing densities of archaeological sites by NUTS2: 6th millennium sites vs. the rest.

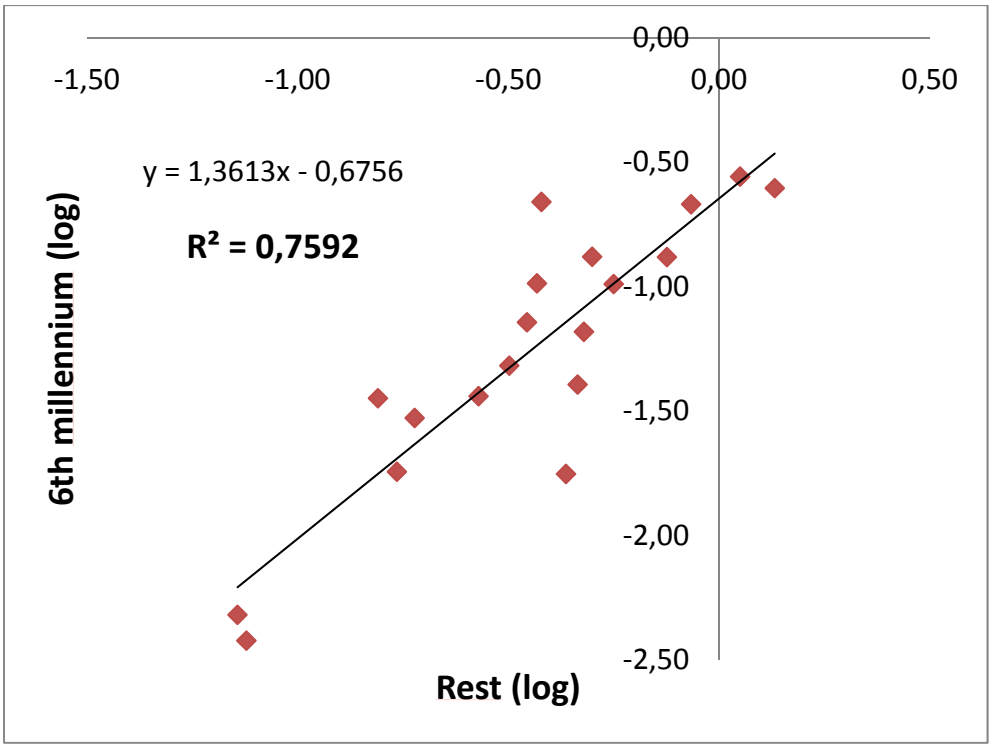

Figure 9. Regression analysis comparing densities of archaeological sites by NUTS2 (log transformed values): 6th millennium sites vs. the rest.

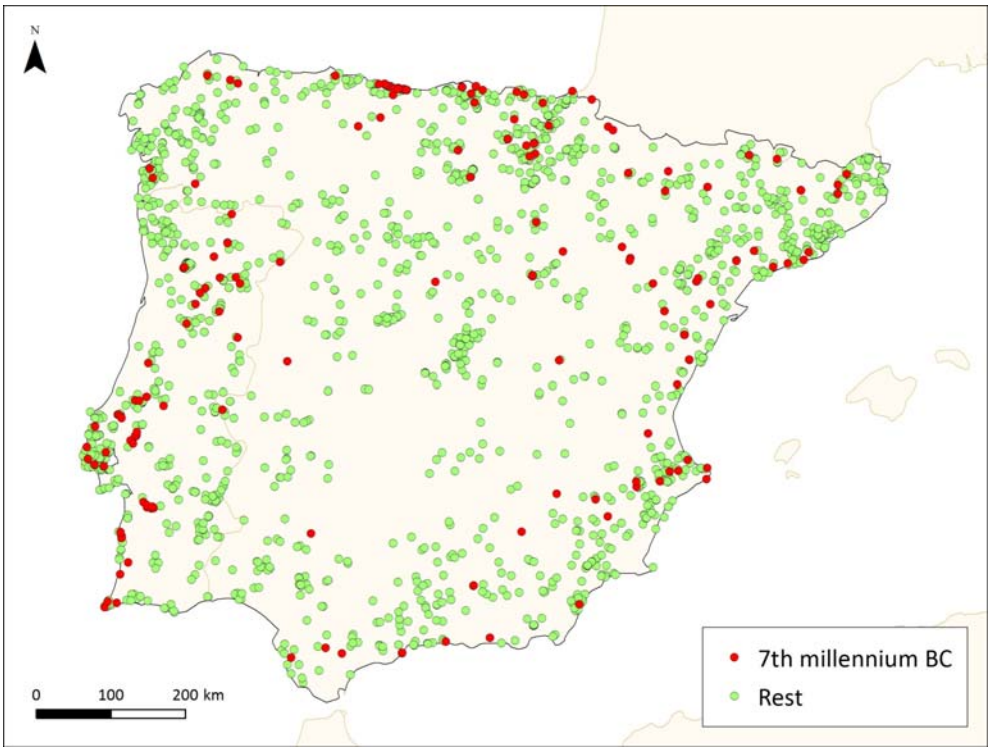

Figure 10. Archaeological sites in the *Radiocarbon Database of Iberian Late Prehistory*, classified into two groups: 7th millennium BC and the rest.

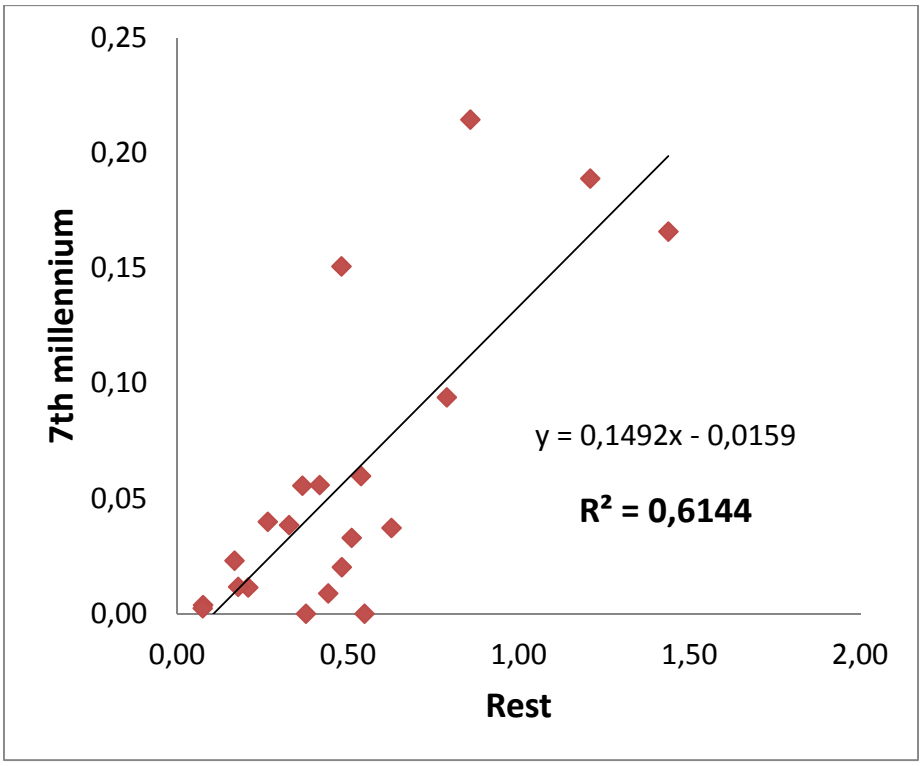

Figure 11. Regression analysis comparing densities of archaeological sites by NUTS2: 7th millennium sites vs. the rest.

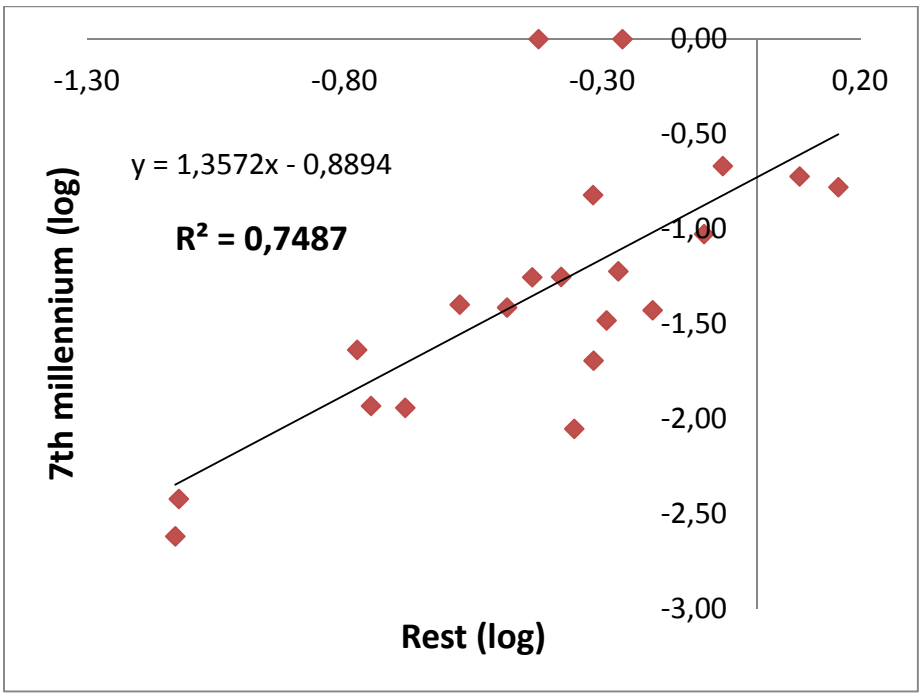

Figure 12. Regression analysis comparing densities of archaeological sites by NUTS2 (log transformed values): 7th millennium sites vs. the rest.